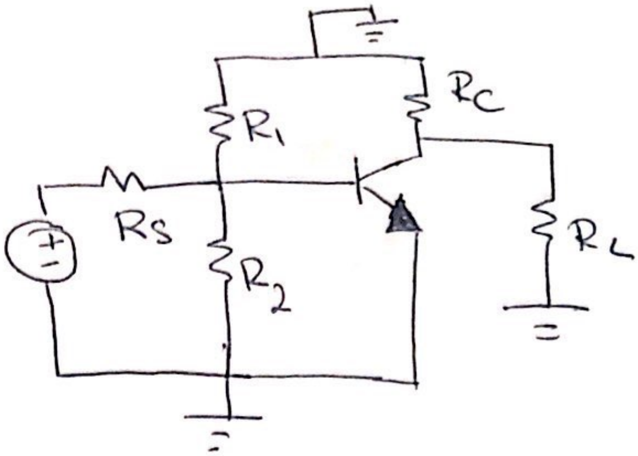
In class problem - Lecture 18

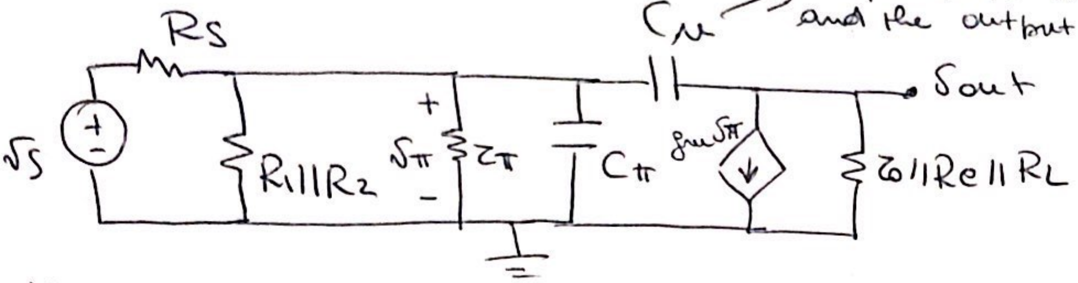
(1)

Determine the upper cut-off frequencies of the given circuit.



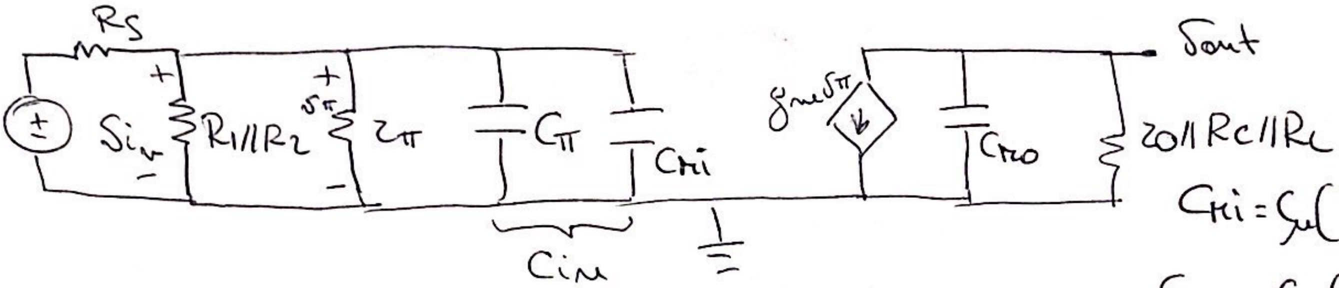
AC CIRCUIT AT HIGH FREQUENCY

Capacitor between the input and the output of the amplifier.



SMALL-SIGNAL EQUIVALENT CIRCUIT AT HIGH FREQUENCY

Using the Miller theorem we can reduce the circuit to above to



$C_{Mi} = C_\mu (1 - A_v)$

$C_{Mo} = C_\mu \left(1 - \frac{1}{A_v}\right)$

$C_{in} = C_{Mi} + C_\pi$ will yield one upper cut-off frequency

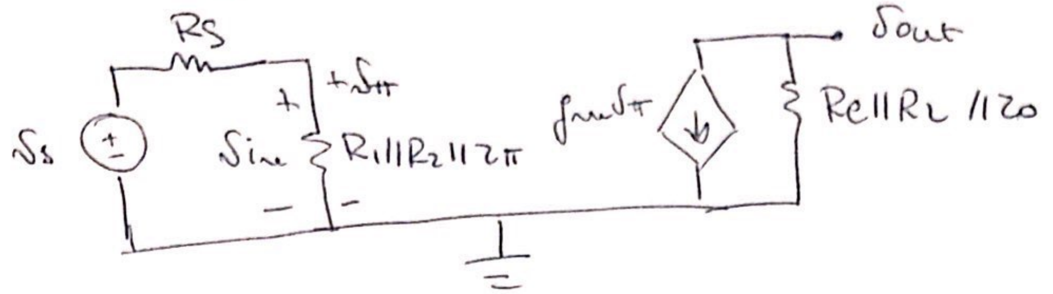
$$f_{H\,in} = \frac{1}{2\pi R_{eq\,in} C_{in}}$$

$C_{out} = C_{Mo}$ will yield one upper cut-off frequency

$$f_{H\,out} = \frac{1}{2\pi R_{eq\,out} C_{out}}$$

A_v is the amplifier midband gain: $A_v = v_{out} / v_{in}$

As we need the midband gain to determine the 2 Miller capacitances, we need to sketch the midband circuit (2)



$$A_V = \frac{V_{out}}{V'_{in}}$$

$$V_{out} = -g_m V_\pi (R_C \| R_L \| r_o)$$

$$V_\pi = V_{in}$$

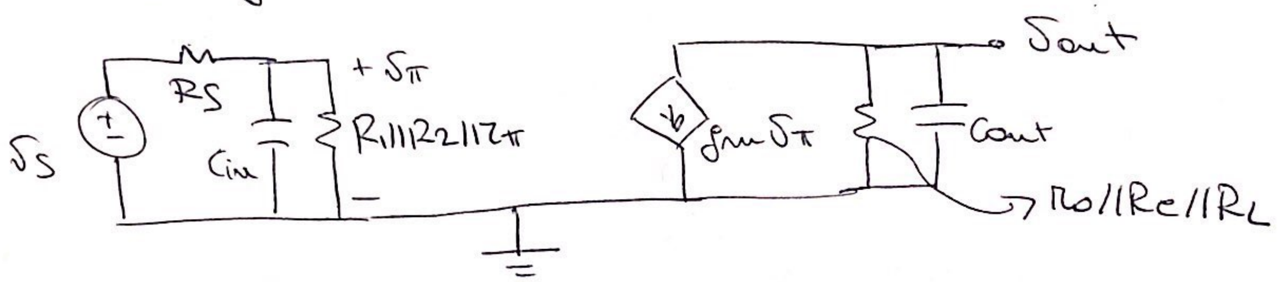
$$A_V = -g_m (R_C \| R_L \| r_o) = -73.35 \text{ V/V}$$

Thus

$$C_{Mi} = C_\mu (1 - A_V) = (2.4p)(74.35) = 178.44 \text{ pF}$$

$$C_{Mo} = C_\mu \left(1 - \frac{1}{A_V}\right) = 2.4p \cdot 1 = 2.4 \text{ pF}$$

Now, going back to the high frequency circuit



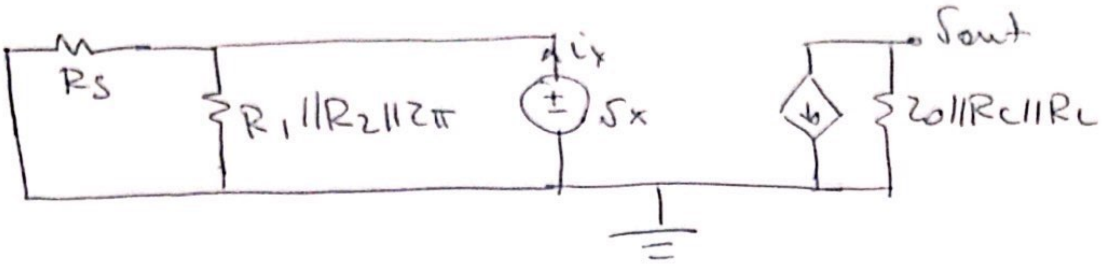
$$C_{in} = C_\pi + C_{Mi} = 20p + 178.44\,p = 198.44 \text{ pF}$$

$$C_{out} = C_{Mo} = 2.4 \text{ pF}$$

To determine the upper cut-off frequencies established by Cin and Cout we need to determine the equivalent resistance seen by the 2 capacitors, namely Reqin and Reqout.

Repin

$V_s = 0 \qquad \frac{1}{j\omega C_{out}} = \infty$ $\qquad$ Cin replaced by a probe source

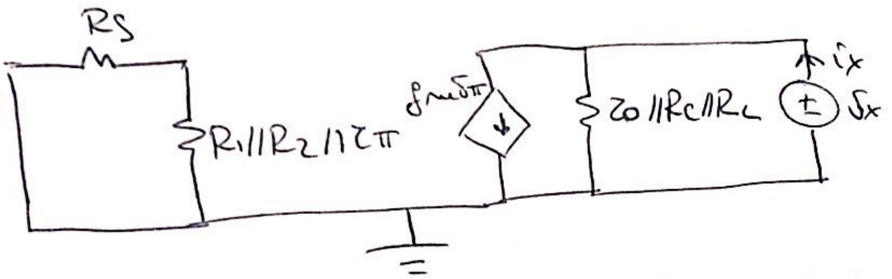


$$R_{epin} = \frac{V_x}{i_x} = R_S \,||\, R_1 \,||\, R_2 \,||\, r_\pi = 389.47\ \Omega$$

$$f_{Hin} = \frac{1}{2\pi\, R_{epin}\, C_{in}} = \frac{1}{2\pi \cdot 389.47 \cdot 198.44p} \simeq 2\ \text{KHz}$$

Repout

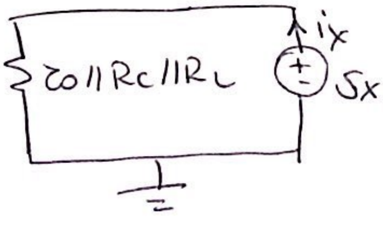
$V_s = 0 \qquad \frac{1}{j\omega C_{in}} = \infty$ $\qquad$ Cout replaced by a probe source.



$$R_{epout} = \frac{V_x}{i_x}$$

$V_\pi = 0 \Rightarrow g_m V_\pi = 0$

Thus the circuit reduces to



$$R_{epout} = \frac{V_x}{i_x} = r_o \,||\, R_C \,||\, R_L = 1.08\text{K}\Omega$$

$$f_{Ho} = \frac{1}{2\pi\, R_{epout}\, C_{out}} \simeq 61.4\ \text{KHz}$$

The two upper corner frequencies of the circuit are

$f_{Hin} \simeq 2\,MHz$ and $f_{Hout} \simeq 61.4\,MHz$

The dominant upper cut-off frequency is the lowest of the two

$$f_H = f_{Hin} \simeq 2\,MHz$$